Mortality Rates

Overall Summary

What is the Mortality Assumption and how is it Used?

Mortality assumptions are primarily used to estimate how long pension benefits will be paid after retirement. We also use these assumptions to determine the probability that a member will survive until retirement. These assumptions are typically gender and age-based.

In analyzing historical data, our goal is to establish assumptions that best estimate the probability of death in a given year for both the member and any eligible survivors. We also set assumptions for how we expect mortality rates to improve over time.

High-Level Takeaways

In general, we are observing improvements in mortality (i.e. members living longer). Our experience indicates that the use of a different projection scale would be prudent; specifically 100 percent of Scale BB. Unlike some other assumptions, we did not exclude data related to the Great Recession.

We believe we have sufficient data to develop our own mortality tables for most plans. Our latest experience supports the continued use of the RP-2000 Combined Healthy Mortality (RP-2000) table for our healthy populations with appropriate age adjustments.

To establish the age offsets, we extended the study period to 12 years of data for purposes of minimizing the volatility in our analysis. Generally, our new offset assumptions did not change by more than one year since the last experience study.

Finally, we chose to simplify our approach to applying these assumptions by making age offsets directly to the RP-2000 table and using generational improvements to project mortality rates every year thereafter. This is a method change from our prior experience study.

Data

We began with 29 years of experience study records, from 1984 to 2012. No special data was added for this assumption, but some data was removed. We chose to remove valuation years 2001 and 2007 since they were, for the most part, only three-fourths of a year.[1]

As noted above, we did not remove data related to the Great Recession, because we do not believe it materially impacted actual mortality rates.

Law Changes

No law changes impacted our selection of mortality assumptions.

[1] *For example, in 2007 the Legislature changed the valuation dates to match the fiscal year. Specifically, the valuation dates changed from September 30 to June 30 of each year.*

Assumptions

All assumptions used in the development of mortality rates match those disclosed in the *2012 Actuarial Valuation Report* (AVR).

General Methodology

Actual mortality rates are calculated as follows. For each year and retirement plan we counted the number of deaths during the year and divided it by the number of members alive at the beginning of the year. This underlying data serves as the basis for setting our mortality assumptions.

We approached this analysis in three steps.

- First, we looked for a trend in the data to determine how mortality rates are improving over time. The results of this analysis were used in selecting a projection scale.
- Next, we reviewed our underlying base mortality table to determine if it remains appropriate or if other published tables may serve as a better fit for our retirement systems.
- Finally, we compared our actual mortality rates during the 2001-2012 period to the base table (projected to the mid-point of the period) for purposes of establishing age offset assumptions.

These steps are explained in more detail below.

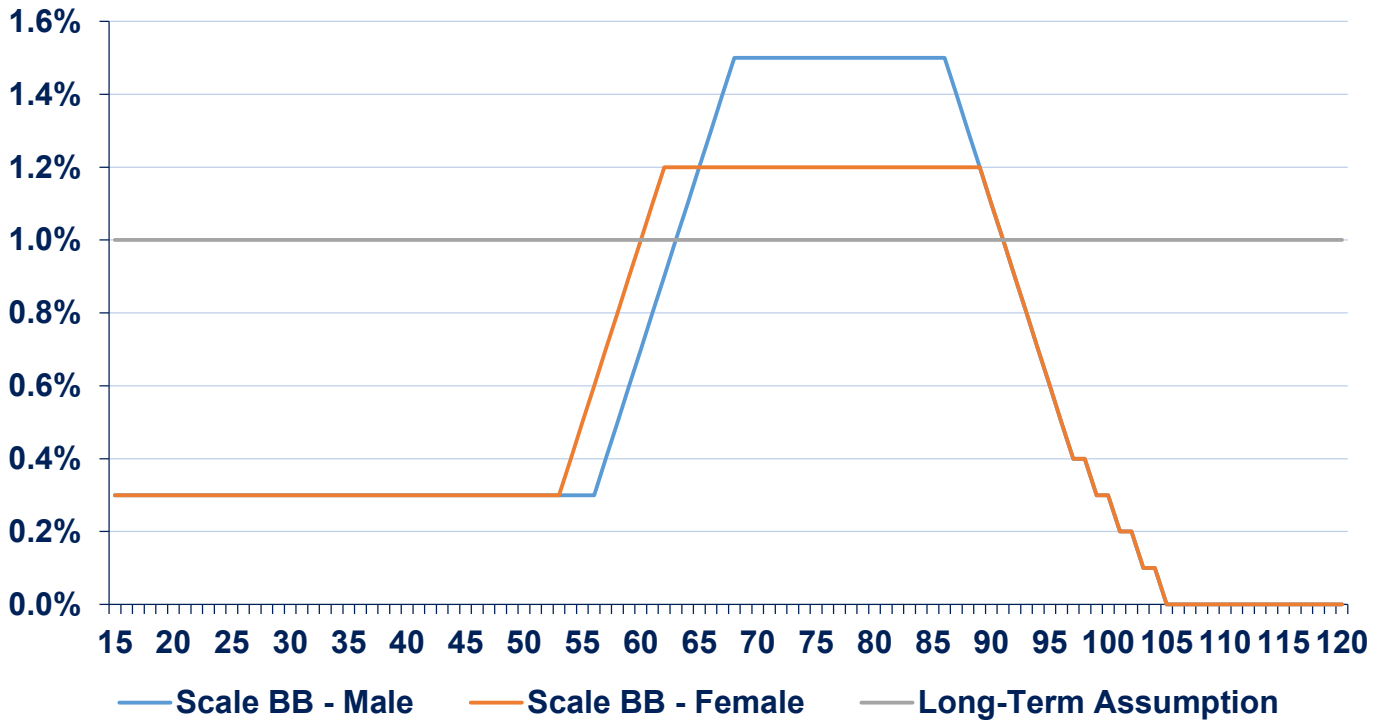
Projection Scale

To select a projection scale, we began by reviewing our actual mortality experience from 1984-2012 and looking at the improvement in mortality at each age. We primarily focused our analysis on the Public Employees' Retirement System (PERS) and the Teachers' Retirement System (TRS), since those two systems accounted for more than 90 percent of deaths across all time-frames studied. We then compared the results of our analysis to scales from the Society of Actuaries (SOA).

There are several scales currently available including: Scale AA, Scale BB, and MP-2014 (proposed). When preparing these scales, the SOA takes into account medical technology and innovation, new treatments and diseases, changes in amount/type of physical activity, changes in nutrition, prevalence of obesity and cigarette smoking, and other factors.

In selecting a mortality improvement scale for our systems, we took a death-weighted average of each system's experience over several time periods. We further eliminated experience that was several multiples higher or lower than the scale we are comparing it to by age (a concept we refer to as an "exclusion percentage").

In determining the exclusion percentage, we reviewed SOA's development of Scale BB. The following graph shows Scale BB by gender and compares it to a 1 percent annual mortality improvement assumption, consistent with the long-term expectations set forth by the SOA's Retirement Plans Experience Committee (RPEC).



We also reviewed a heat map from the Scale BB report that illustrates a range of experience from -1.5 percent to 5.0 percent annual mortality improvement.

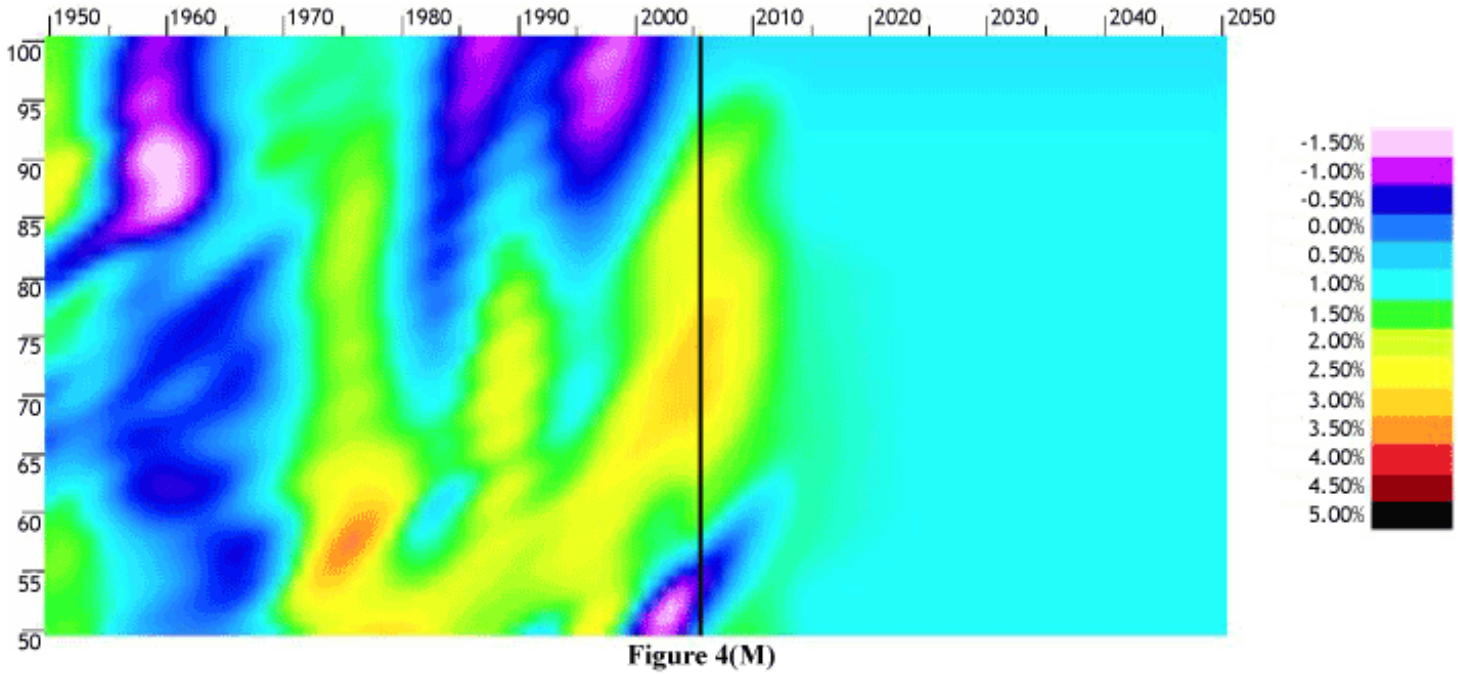


Figure 4(M)

We defined the exclusion percentage as the ratio of our mortality improvement experience by age compared to the scale of interest, where ratios larger in magnitude are excluded as outliers. Comparing the long-term RPEC assumption to the range provided in the heat maps, the use of an exclusion percentage around 350-650 percent seems reasonable.

Ultimately, we selected an exclusion percentage of 500 percent; or rather, have chosen to remove outlier experience that was larger in magnitude than five times the mortality improvement scale assumption at each age. The following tables summarize the healthy mortality improvement experience under our best-estimate exclusion percentage of 500 percent.

Observations as a % of Scale			
(Using a 500% Exclusion)			# of Deaths
Data Range	Scale AA	Scale BB	All System
1984-2012	109%	78%	84,949
1990-2012	152%	97%	72,307
1996-2012	204%	127%	56,118
2001-2012	143%	136%	40,101

We further include sensitivity of the results around the exclusion percentage assumption.

Observations as a % of Scale		
(Using a 300% Exclusion)		
Data Range	Scale AA	Scale BB
1984-2012	108%	70%
1990-2012	114%	81%
1996-2012	95%	102%
2001-2012	57%	110%
(Using a 700% Exclusion)		
Data Range	Scale AA	Scale BB
1984-2012	113%	86%
1990-2012	155%	107%
1996-2012	177%	147%
2001-2012	262%	158%

Note that our approach simply assigned 0 percent of the mortality improvement scale to the outliers. Alternatively, we could remove the weighting entirely from these observations. Below you'll find a table that illustrates that choice. We concluded that the difference between the two approaches would not change our conclusions.

PERS Observations as a % of Scale				
	Original Results		*Excluding Outliers*	
Data Range	AA	BB	AA	BB
1984-2012	133%	91%	137%	96%
1990-2012	179%	111%	185%	117%
1996-2012	266%	155%	281%	167%
2001-2012	170%	155%	238%	171%

At this point we do not plan to use the MP-2014 mortality projection scale since it is still preliminary. However, we will continue to review this in future studies.

Base Mortality Table

We reviewed the use of the RP-2000 Combined Healthy Mortality (RP-2000) table compared to separate Active/Employee and Retired tables. With PERS as an example, of the approximately 14,200 deaths during the experience study period, only about 1,200 were attributable to active and terminated vested members. Given that amount of data, we decided the use of separate mortality tables was not warranted.

Further, many of the early retirees in our plans do not leave the workforce. Rather, they just retire from public service or retire from their current occupation and continue to work in the private sector or in other occupations. As such, we believe active mortality is a better predictor of future mortality for these early retirees than an annuitant-based mortality table.

Please note that at this point, we do not plan to use the RP-2014 mortality tables for the same reason that we are not using the MP-2014 mortality projection scale. Further, the SOA has mentioned the possibility of a future study on public retirement system mortality. This suggests to us that RP-2014 may not be the best fit for our plans.

Age Offsets

Age offsets are the result of analyzing the difference between our actual mortality experience and the underlying base table (RP-2000). In other words, we use RP-2000 as a base reference point, then adjust the table to better model our experience.

To determine age offsets, we project the RP-2000 table to the midpoint of the 12-year study period (2006) using the chosen mortality improvement scale. We then summed the weighted differences in our actual mortality experience by age compared to the RP-2006 table. Finally, we tested a variety of age offsets with the goal of minimizing the magnitude of these weighted differences. The table below provides a high-level overview of the Actual to Expected (A/E) experience under a variety of age offsets.

Weighted Average A/E Experience

PERS				SERS			
Offsets	*Male*	Offsets	*Female*	Offsets	*Male*	Offsets	*Female*
-2	1.111	-2	1.131	-3	1.000	-3	0.736
-1	1.001	-1	1.025	-2	0.902	-2	0.664
0	0.903	0	0.930	0	0.733	0	0.541
1	0.815	1	0.847	1	0.661	1	0.487
TRS				**PSERS**			
Offsets	*Male*	Offsets	*Female*	Offsets	*Male*	Offsets	*Female*
-4	1.110	-3	1.115	-2	N/A	-2	N/A
-3	0.999	-2	1.013	-1	N/A	-1	N/A
0	0.732	0	0.846	0	N/A	0	N/A
1	0.662	1	0.776	1	N/A	1	N/A
LEOFF				**WSPRS**			
Offsets	*Male*	Offsets	*Female*	Offsets	*Male*	Offsets	*Female*
-2	1.117	2	0.993	3	0.994	3	N/A
-1	1.005	1	1.093	2	1.096	2	N/A
0	0.906	0	1.207	0	1.339	0	N/A
1	0.816	-1	1.335	-1	1.484	-1	N/A

Milliman, the auditing actuarial consulting firm that reviewed our analysis, provided a suggested improvement for determining age offsets. Specifically, at their recommendation, we investigated the use of benefit-weighted analysis (as opposed to death-weighted). This approach could more accurately model plan liabilities by placing more weight on those receiving larger pension payments when setting mortality assumptions. However, our preliminary analysis did not indicate this would materially impact our assumptions at this time. We plan to use this new method and will continue to monitor this assumption in future experience studies.

Results

All-Plan Summary

In general, we observed improvements in mortality (i.e. members living longer). Our experience indicates that the use of a different projection scale would be prudent, specifically 100 percent of Scale BB.

We believe we have sufficient data to develop our own mortality tables. Our latest experience supports the continued use of the RP-2000 table (with age adjustments where warranted) for our healthy populations.

Assumption Format

We simplified our approach from how we previously applied the mortality improvement and age offset assumptions. Specifically, we made age offsets directly to the RP-2000 table and use generational mortality improvements to project mortality rates every year thereafter.

Our old methodology projected the RP-2000 table to the mid-point of the experience study period, applied the age offsets, then further projected the table to a static year in the future for purposes of approximating the liability impact of using generational mortality improvements.

Best Estimate Mortality Rates

Healthy Mortality

Projection Scale

We considered our expectations for the future and how those expectations may impact the observed trends. Then, we compared our conclusions with the available mortality scales and picked the scale we felt best reflects mortality trends for the Washington State retirement systems. For this study we selected 100 percent of Scale BB, whereas we previously used 50 percent of Scale AA.

100% of Scale BB														
Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female
20	0.003	0.003	40	0.003	0.003	60	0.007	0.010	80	0.015	0.012	100	0.003	0.003
21	0.003	0.003	41	0.003	0.003	61	0.008	0.011	81	0.015	0.012	101	0.002	0.002
22	0.003	0.003	42	0.003	0.003	62	0.009	0.012	82	0.015	0.012	102	0.002	0.002
23	0.003	0.003	43	0.003	0.003	63	0.010	0.012	83	0.015	0.012	103	0.001	0.001
24	0.003	0.003	44	0.003	0.003	64	0.011	0.012	84	0.015	0.012	104	0.001	0.001
25	0.003	0.003	45	0.003	0.003	65	0.012	0.012	85	0.015	0.012	105	0.000	0.000
26	0.003	0.003	46	0.003	0.003	66	0.013	0.012	86	0.015	0.012	106	0.000	0.000
27	0.003	0.003	47	0.003	0.003	67	0.014	0.012	87	0.014	0.012	107	0.000	0.000
28	0.003	0.003	48	0.003	0.003	68	0.015	0.012	88	0.013	0.012	108	0.000	0.000
29	0.003	0.003	49	0.003	0.003	69	0.015	0.012	89	0.012	0.012	109	0.000	0.000
30	0.003	0.003	50	0.003	0.003	70	0.015	0.012	90	0.011	0.011	110	0.000	0.000
31	0.003	0.003	51	0.003	0.003	71	0.015	0.012	91	0.010	0.010	111	0.000	0.000
32	0.003	0.003	52	0.003	0.003	72	0.015	0.012	92	0.009	0.009	112	0.000	0.000
33	0.003	0.003	53	0.003	0.003	73	0.015	0.012	93	0.008	0.008	113	0.000	0.000
34	0.003	0.003	54	0.003	0.004	74	0.015	0.012	94	0.007	0.007	114	0.000	0.000
35	0.003	0.003	55	0.003	0.005	75	0.015	0.012	95	0.006	0.006	115	0.000	0.000
36	0.003	0.003	56	0.003	0.006	76	0.015	0.012	96	0.005	0.005	116	0.000	0.000
37	0.003	0.003	57	0.004	0.007	77	0.015	0.012	97	0.004	0.004	117	0.000	0.000
38	0.003	0.003	58	0.005	0.008	78	0.015	0.012	98	0.004	0.004	118	0.000	0.000
39	0.003	0.003	59	0.006	0.009	79	0.015	0.012	99	0.003	0.003	119	0.000	0.000
												120	0.000	0.000

Base Mortality Table

Based on our analysis, we think the continued use of the RP-2000 table is appropriate. Please see these mortality rates in the table below.

RP-2000 Combined Healthy Mortality Table														
Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female
20	0.000345	0.000191	40	0.001079	0.000706	60	0.006747	0.005055	80	0.064368	0.045879	100	0.344556	0.237467
21	0.000357	0.000192	41	0.001142	0.000774	61	0.007676	0.005814	81	0.072041	0.050780	101	0.358628	0.244834
22	0.000366	0.000194	42	0.001215	0.000852	62	0.008757	0.006657	82	0.080486	0.056294	102	0.371685	0.254498
23	0.000373	0.000197	43	0.001299	0.000937	63	0.010012	0.007648	83	0.089718	0.062506	103	0.383040	0.266044
24	0.000376	0.000201	44	0.001397	0.001029	64	0.011280	0.008619	84	0.099779	0.069517	104	0.392003	0.279055
25	0.000376	0.000207	45	0.001508	0.001124	65	0.012737	0.009706	85	0.110757	0.077446	105	0.397886	0.293116
26	0.000378	0.000214	46	0.001616	0.001223	66	0.014409	0.010954	86	0.122797	0.086376	106	0.400000	0.307811
27	0.000382	0.000223	47	0.001734	0.001326	67	0.016075	0.012163	87	0.136043	0.096337	107	0.400000	0.322725
28	0.000393	0.000235	48	0.001860	0.001434	68	0.017871	0.013445	88	0.150590	0.107303	108	0.400000	0.337441
29	0.000412	0.000248	49	0.001995	0.001550	69	0.019802	0.014860	89	0.166420	0.119154	109	0.400000	0.351544
30	0.000444	0.000264	50	0.002138	0.001676	70	0.022206	0.016742	90	0.183408	0.131682	110	0.400000	0.364617
31	0.000499	0.000307	51	0.002449	0.001852	71	0.024570	0.018579	91	0.199769	0.144604	111	0.400000	0.376246
32	0.000562	0.000350	52	0.002667	0.002018	72	0.027281	0.020665	92	0.216605	0.157618	112	0.400000	0.386015
33	0.000631	0.000394	53	0.002916	0.002207	73	0.030387	0.022970	93	0.233662	0.170433	113	0.400000	0.393507
34	0.000702	0.000435	54	0.003196	0.002424	74	0.033900	0.025458	94	0.250693	0.182799	114	0.400000	0.398308
35	0.000773	0.000475	55	0.003624	0.002717	75	0.037834	0.028106	95	0.267491	0.194509	115	0.400000	0.400000
36	0.000841	0.000514	56	0.004200	0.003090	76	0.042169	0.030966	96	0.283905	0.205379	116	0.400000	0.400000
37	0.000904	0.000554	57	0.004693	0.003478	77	0.046906	0.034105	97	0.299852	0.215240	117	0.400000	0.400000
38	0.000964	0.000598	58	0.005273	0.003923	78	0.052123	0.037595	98	0.315296	0.223947	118	0.400000	0.400000
39	0.001021	0.000648	59	0.005945	0.004441	79	0.057927	0.041506	99	0.330207	0.231387	119	0.400000	0.400000
												120	1.000000	1.000000

Age Offsets

Generally, we observed that the retirement systems' experience matches those in the RP-2006 table who are about a year younger (a negative age offset). Some plans had relatively little experience in terms of total deaths over the period. As a result, we relied on their general relationship to the larger plans where appropriate when setting these assumptions for males and females.

The table below summarizes the new and old age offset assumptions.

Offset Assumptions

Analysis of Mortality Table Offsets	PERS All Plans		TRS All Plans		SERS Plan 2/3	
	Male	Female	Male	Female	Male	Female
Old	-1	-1	-2	-2	0	-2
New	-1	-1	-3	-2	-1	-1
Analysis of Mortality Table Offsets	**PSERS Plan 2**		**LEOFF All Plans**		**WSPRS Plan 1/2**	
	Male	Female	Male	Female	Male	Female
Old	-1	-1	-1	1	-1	1
New	-1	-1	-1	1	-1	1

Deaths	PERS	TRS	SERS	LEOFF	WSPRS	Total
2001-2012	27,195	10,406	979	1,365	156	40,101

We believe we have insufficient data to set system-specific mortality tables for the School Employees' Retirement System (SERS) and the Public School Employees' Retirement System (PSERS). As a result, we decided to rely on PERS experience for purposes of setting SERS and PSERS offsets. Given the nature of most SERS and PSERS jobs, we might see slightly higher actual rates of mortality for these plans than for PERS in the future. However, the use of PERS mortality provides a reasonable amount of conservatism given the uncertainty in this area. Similarly, we relied on the Law Enforcement Officers' and Fire Fighters' Plan 2 Retirement System (LEOFF) experience when setting this assumption for the Washington State Patrol Retirement System (WSPRS).

Although our data indicates a +2 age offset would be reasonable for LEOFF females, we decided to retain our current assumption of +1. A vast majority of deaths from this system for females are survivors (not female law enforcement officers or fire fighters), and data is limited. It's also reasonable to expect them to be similar to the general population (or PERS, perhaps).

Examples

The following examples will help illustrate how these assumption components are combined. For instance, we calculate the mortality rate as of the year 2001 for a male aged 25 and a female aged 70 given the age offsets for TRS. Note that this concept can be extrapolated for each year in the future.

An age 25 male with a −3 offset is assumed to have mortality experience consistent with a 22-year-old male; similarly, the age 70 female with that of a 68-year-old female for a −2 age offset. As of the year 2000, the age 22 (=25−3) male and age 68 (=70−2) female mortality rates are 0.000366 and 0.013445, respectively. This means that we expect there is a 0.0366 percent chance that a TRS male age 25 will die by the end of the year. As might be expected, the TRS female age 70 is assumed to have 1.3445 percent chance of dying before 2001.

The Scale BB improvements for these example members are 0.003 male and 0.012 female at those ages. In other words, the age 25 male mortality rate is expected to decrease by 0.3 percent each year and the age 70 female mortality rate by 1.2 percent. The following shows one year of this calculation. Projected to 2001, an age 25 male and an age 70 female in TRS will have corresponding mortality rates of 0.000365 [= 0.000366 * (1−0.003)] and 0.013284 [= 0.013445 * (1−0.012)].

Disabled Mortality

We reviewed the continued use of the RP-2000 Combined Disabled Mortality table. Based on our analysis of all plans combined (excluding LEOFF 1), we believe this remains reasonable. Please see these disabled mortality rates in the table below.

RP-2000 Combined Disabled Mortality Table													
Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female	Age	Male	Female
20	0.022571	0.007450	40	0.022571	0.007450	60	0.042042	0.021839	80	0.109372	0.072312	100	0.344556	0.237467
21	0.022571	0.007450	41	0.022571	0.007450	61	0.043474	0.022936	81	0.115544	0.077135	101	0.358628	0.244834
22	0.022571	0.007450	42	0.022571	0.007450	62	0.044981	0.024080	82	0.121877	0.082298	102	0.371685	0.254498
23	0.022571	0.007450	43	0.022571	0.007450	63	0.046584	0.025293	83	0.128343	0.087838	103	0.383040	0.266044
24	0.022571	0.007450	44	0.022571	0.007450	64	0.048307	0.026600	84	0.134923	0.093794	104	0.392003	0.279055
25	0.022571	0.007450	45	0.022571	0.007450	65	0.050174	0.028026	85	0.141603	0.100203	105	0.397886	0.293116
26	0.022571	0.007450	46	0.023847	0.008184	66	0.052213	0.029594	86	0.148374	0.107099	106	0.400000	0.307811
27	0.022571	0.007450	47	0.025124	0.008959	67	0.054450	0.031325	87	0.155235	0.114512	107	0.400000	0.322725
28	0.022571	0.007450	48	0.026404	0.009775	68	0.056909	0.033234	88	0.162186	0.122464	108	0.400000	0.337441
29	0.022571	0.007450	49	0.027687	0.010634	69	0.059613	0.035335	89	0.169233	0.130972	109	0.400000	0.351544
30	0.022571	0.007450	50	0.028975	0.011535	70	0.062583	0.037635	90	0.183408	0.140049	110	1.000000	1.000000
31	0.022571	0.007450	51	0.030268	0.012477	71	0.065841	0.040140	91	0.199769	0.149698	111	1.000000	1.000000
32	0.022571	0.007450	52	0.031563	0.013456	72	0.069405	0.042851	92	0.216605	0.159924	112	1.000000	1.000000
33	0.022571	0.007450	53	0.032859	0.014465	73	0.073292	0.045769	93	0.233662	0.170433	113	1.000000	1.000000
34	0.022571	0.007450	54	0.034152	0.015497	74	0.077512	0.048895	94	0.250693	0.182799	114	1.000000	1.000000
35	0.022571	0.007450	55	0.035442	0.016544	75	0.082067	0.052230	95	0.267491	0.194509	115	1.000000	1.000000
36	0.022571	0.007450	56	0.036732	0.017598	76	0.086951	0.055777	96	0.283905	0.205379	116	1.000000	1.000000
37	0.022571	0.007450	57	0.038026	0.018654	77	0.092149	0.059545	97	0.299852	0.215240	117	1.000000	1.000000
38	0.022571	0.007450	58	0.039334	0.019710	78	0.097640	0.063545	98	0.315296	0.223947	118	1.000000	1.000000
39	0.022571	0.007450	59	0.040668	0.020768	79	0.103392	0.067793	99	0.330207	0.231387	119	1.000000	1.000000
												120	1.000000	1.000000

Since we chose to use Scale BB with our Healthy mortality tables, and in light of our actual disabled mortality experience from our latest study, we decided to apply Scale BB for Disabled mortality improvements. Otherwise, we did not make any changes to the disabled mortality assumptions since the last experience study.

We analyzed how well PERS observations compared to the mortality improvement scales and reviewed the age offsets for PERS and LEOFF 1. Given the limited data as noted in the table below, we decided to analyze all disabled mortality data together (with and without LEOFF 1). The following table shows the counts of actual deaths of disabled members in the plans between 2001 and 2012.

Deaths (Disabled)		PERS	TRS	SERS	LEOFF 1	LEOFF 2	WSPRS	Total
2001-2012	Male	787	123	32	835	15	14	1,806
	Female	756	194	36	6	15	1	1,008
	Total	**1,543**	**317**	**68**	**841**	**30**	**15**	**2,814**

The next table summarizes the disabled mortality improvement experience under our best estimate exclusion percentage of 500 percent. We further include sensitivity of the results around that assumption. However, given the limited experience data (in terms of the number of disabled members who have died), we ultimately decided to rely on the mortality improvement assumption set for our healthy population, 100 percent of Scale BB.

Observations as a % of Scale						
Exclusion %	300%		500%		700%	
Data Range	AA	BB	AA	BB	AA	BB
1984-2012	58%	63%	78%	90%	101%	237%
1990-2012	69%	59%	87%	113%	100%	147%
1996-2012	50%	73%	94%	75%	79%	143%
2001-2012	20%	11%	11%	77%	85%	60%

We continue to observe that mortality experience in LEOFF 1 is closer to a healthier population than a disabled population. Their experience was compared to the RP-2000 Combined Healthy Mortality table for purposes of determining age offsets. Consistent with the prior assumption, we will continue to apply a +2 age offset for all disabled members in LEOFF 1.

All other plans will continue to use a zero age offset assumption with the RP-2000 Combined Disabled Mortality table. The table below provides a high-level overview of the A/E experience.

Weighted Average A/E Experience

LEOFF 1 w/ Healthy Mortality				All Plans w/o LEOFF 1			
Offsets	Male	Offsets	Female*	Offsets	Male	Offsets	Female
3	0.964	3	3.930	3	0.862	3	1.154
2	1.067	2	4.333	1	0.947	1	1.287
0	1.313	0	5.322	0	0.991	0	1.358
-1	1.460	-1	5.895	-1	1.036	-1	1.434

** LEOFF 1 only had 6 female disabled deaths over the 12-year period.*